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UTILITY PATENT APPLICATION TRANSMITTAL
(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. _06089.P007___   Total Pages _2___

First Named Inventor or Application Identifier _Kapil D. Singh_

Express Mail Label No. _EL034432036US_

ADDRESS TO: **Assistant Commissioner for Patents**
               Box Patent Application
               Washington, D. C. 20231

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

1.   _X_   Fee Transmittal Form
             (Submit an original, and a duplicate for fee processing)

2.   _X_   Specification   (Total Pages ___24___)
             (preferred arrangement set forth below)
             - Descriptive Title of the Invention
             - Cross References to Related Applications
             - Statement Regarding Fed sponsored R & D
             - Reference to Microfiche Appendix
             - Background of the Invention
             - Brief Summary of the Invention
             - Brief Description of the Drawings (if filed)
             - Detailed Description
             - Claims
             - Abstract of the Disclosure

3.   _X_   Drawings(s) (35 USC 113)   (Total Sheets _5__)

4.   _X_   Oath or Declaration   (Total Pages _3___)   UNSIGNED
         a.   ___   Newly Executed (Original or Copy)
         b.   ___   Copy from a Prior Application (37 CFR 1.63(d))
                       (for Continuation/Divisional with Box 17 completed) **(Note Box 5 below)**
         i.   ___   DELETIONS OF INVENTOR(S) Signed statement attached deleting
                       inventor(s) named in the prior application, see 37 CFR 1.63(d)(2)
                       and 1.33(b).

5.   _   Incorporation By Reference (useable if Box 4b is checked)
             The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6.   _   Microfiche Computer Program (Appendix)

7.   _   Nucleotide and/or Amino Acid Sequence Submission
      (if applicable, all necessary)
         a.   ____   Computer Readable Copy
         b.   ____   Paper Copy (identical to computer copy)
         c.   ____   Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. _____ Assignment Papers (cover sheet & documents(s))

9. _____ a. 37 CFR 3.73(b) Statement (where there is an assignee)

_____ b. Power of Attorney

10. _____ English Translation Document (if applicable)

11. _____ a. Information Disclosure Statement (IDS)/PTO-1449

_____ b. Copies of IDS Citations

12. _____ Preliminary Amendment

13. __X__ Return Receipt Postcard (MPEP 503) (Should be specifically itemized)

14. _____ a. Small Entity Statement(s)

b. Statement filed in prior application, Status still proper and desired

15. _____ Certified Copy of Priority Document(s) (if foreign priority is claimed)

16. __X__ Other: <u>Separate Sheet: Certificate of Mailing with Attorney Signature and copy of</u>
<u>return postcard.</u>

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17. **If a CONTINUING APPLICATION,** check appropriate box and supply the requisite information:

____ Continuation ____ Divisional ____ Continuation-in-part (CIP)

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18. **Correspondence Address**

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APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

Method And Apparatus
For Reusing Subparts Of One Mechanical Design For Another Mechanical Design

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"Express Mail" mailing label number EL034432036US

Date of Deposit January 28, 1999

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Method and Apparatus for Reusing Subparts Of One Mechanical Design In Another Design

BACKGROUND OF THE INVENTION

5

1. Field of the Invention

The present invention relates to the field of computer aided design (CAD). More specifically, the present invention relates to reusing subparts of one

10 mechanical design in another mechanical design.

2. Background Information

Prior art CAD tools typically describe a mechanical design in terms of

15 various geometric shapes, also referred to as "parts". Each part in turn is expressed as a step-by-step recipe incrementally building the various features of the geometric shape, with each step roughly corresponds to a feature. In other words, each part is formed through a linear sequence of steps. For example, a linear step sequence may specify a particular geometric shape is to be formed by starting with a block,

20 cutting a slot at a first location (a first feature), then cutting another angled slot at a second location (a second feature), and so forth. By changing the different design parameters of the "recipe", different embodiments of the geometric shape may be built.

25 The prior art linear sequence approach to modeling geometric shapes of a mechanical design suffers from at least a number of disadvantages:

a) a significant number of topics or issues associated with the modeling of a mechanical design can not be expressed as features, e.g. equations to create cost, stress and so forth;

b) linear sequences are difficult to manipulate and re-order; and

5   c) linear sequences do not adapt well to reuse analysis, i.e. the reuse of a subpart of one mechanical design in another mechanical design.

The fact that linear sequences do not adapt well to reuse analysis is especially problematic for CAD tools, as increasingly, mechanical designers desire

10   to be able to reuse various subparts of their mechanical designs, in particular, the "standard" or "common" building block subparts employed in otherwise highly complex mechanical designs. Thus, a more effective and efficient approach to expressing mechanical designs and facilitating manipulation of the mechanical designs to allow different subparts of one mechanical design to be easily reuse in

15   another, is desired.

SUMMARY OF THE INVENTION

5   A mechanical design reuse method includes having a CAD tool replicates a subset of a first modeling representation of a first mechanical design, in response to having received instructions that identify a subpart of the first mechanical design. The reuse method further includes having the CAD tool merges the replicated subset into a second modeling representation of a second mechanical design to effectuate the reuse of the identified subpart of the first mechanical design

10   in the second mechanical design.

In one embodiment, the modeling representations are dependent graphs, and the subsets being replicated and merged are sub-graphs of the dependent graphs. The dependent graphs and sub-graphs include nodes directly

15   associated with subparts of the mechanical designs, nodes the directly associated nodes are dependent on, and arcs linking these nodes together in accordance with their dependency on one another. In one embodiment, the replicate and merging process also provides for a designer the option to transform certain design variables having constant values assigned to become design variables eligible to have their

20   values variably assigned, and vice versa.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will be described by way of exemplary embodiments, but not limitations, illustrated in the accompanying drawings in which

5   like references denote similar elements, and in which:

Figure 1 illustrates an overview of the present invention in accordance with one embodiment;

Figures 2a-2c illustrate a mechanical design, its data and its dependent graph in accordance with one example;

10   **Figure 3** illustrate the method of the present invention for viewing a mechanical design and its dependent graph in accordance with one embodiment;

Figure 4 illustrates the method of the present invention for reusing subparts of a mechanical design in another mechanical design in accordance with one embodiment; and

15   **Figure 5** illustrates one embodiment of a computer system suitable for programming with instructions implementing the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the following description, various aspects of the present invention will be described. However, it will be apparent to those skilled in the art that the present

5   invention may be practiced with only some or all aspects of the present invention. For purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of the present invention. However, it will also be apparent to one skilled in the art that the present invention may be practiced without the specific details. In other instances, well known features are

10   omitted or simplified in order not to obscure the present invention.

Parts of the description will be presented in terms of operations performed by a computer system, using terms such as data, flags, bits, values, characters, strings, numbers and the like, consistent with the manner commonly

15   employed by those skilled in the art to convey the substance of their work to others skilled in the art. As well understood by those skilled in the art, these quantities take the form of electrical, magnetic, or optical signals capable of being stored, transferred, combined, and otherwise manipulated through mechanical and electrical components of the computer system; and the term computer system include general

20   purpose as well as special purpose data processing machines, systems, and the like, that are standalone, adjunct or embedded.

Various operations will be described as multiple discrete steps in turn, in a manner that is most helpful in understanding the present invention, however, the

25   order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations need not be performed

in the order of presentation. The phrase "in one embodiment" will be employed from time to time, and it is not intended to necessarily refer to the same embodiment.

5   Referring now **Figure 1**, wherein a block diagram illustrating an overview of the present invention in accordance with one embodiment is shown. As illustrated, CAD tool **100** includes modeler **102** and browser **104**. As in prior art, modeler **102** models mechanical designs (hereinafter, simply designs), while browser **104** facilitates display of the modeled designs and related information for the designer, as well as facilitates input by the designer. However, unlike prior art,

10   in accordance with the present invention, modeler **102** models designs employing dependent graphs, and using data **106a-106b** suitably organized for the dependent graph approach, to be described more fully below, whereas browser **104** not only facilitates display of the designs **108a-108b** and their dependant graphs **110a-110b**, but facilitates their displays in a novel coordinated manner. As will be readily

15   apparent from the description to follow, the present invention advantageously enables a designer to be able to efficiently reuse subparts of one design in another design. In particular, the present invention advantageously enables a designer to be able to efficiently explore the interrelationship between various subparts of a modeled design and its dependant paragraph, thereby allowing the designer to

20   efficiently leverage on the reuse support offered by CAD tool **100**.

        Except for the teachings of the present invention incorporated, modeler **102** and browser **104** are otherwise intended to represent a broad range of these elements known in the art. Thus, except for the teachings incorporated, which

25   are described in more details below, modeler **102** and browser **104** will not be otherwise further described.

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Referring now to **Figures 2a-2c**, wherein three diagrams illustrating the relationship between an example modeled design, its data and dependent graph, in accordance with one embodiment, are shown. As illustrated in **Fig. 2a**,

5   example design **200** is a simple rectangle having four sides A through D. **Fig. 2b**, illustrates example dependent graph **202** employed by modeler **102** to model design **200**. As illustrated, example dependent graph **202** includes nodes **204**, nodes **206**, and arcs **208** linking nodes **204** and **206** to one another. Nodes **204** and **206** represent "atomic" design variables of example design **200**, i.e. they represent the

10   "lowest level" information building blocks for modeling example design **200**. Examples of these "lowest level" information building blocks are numbers, lines, points, and so forth. Nodes **204** are referred to as independent nodes representing independent design variables, whereas nodes **206** are referred to as dependent nodes representing dependent design variables. Dependent design variables are

15   those design variables that cannot be resolved until other design variables are resolved first. Thus, arcs **208** represent dependencies between the design variables represented by nodes **204** and **206**. For examples, nodes **206** directly representing lines A-D of rectangle **200** are linked to nodes **204** defining lines A-D's dimension, as well as to one another, by arcs **208** representing the "length of",

20   perpendicular, and parallel relationships between these nodes. Two example types of "dimension" nodes **204** are illustrated, "3 cm" and "<user input>". Nodes **206** linked to "3 cm" node **204** represent the length of the lines represented by the particular nodes **206** are invariantly assigned the value "3 cm", whereas nodes **206** linked to "<user input>" node **204** " represent the length of the lines represented by

25   the particular nodes **206** are eligible to have their lengths variably assigned by the designer.

As shown in **Fig. 2c**, for the illustrated embodiment, the descriptive data of example design **200** processed by modeler **102** to generate dependent graph **202** are organized in a tabular manner. As those skilled in the art will

5   appreciate that any one of a number of other known data organizations may also be employed to store the descriptive data of a design.

Furthermore, while for ease of understanding, the interrelationships between a design, its data and its dependent graph have been illustrated with the

10   simple example design of a rectangle, as those skilled in the art will appreciate that the principles are nevertheless fully scalable to highly complex designs having large quantities of data and complicated dependent graphs.

Referring now to **Figure 3**, wherein a flow diagram illustrating the

15   operational flow of browser **104** for facilitating exploration of a modeled design and its dependent graph, in accordance with one embodiment, is shown. As illustrated, at **302**, browser **104** receives certain selection inputs from the user. The selection may be denoted and communicated to browser **104** in any one of a number of techniques known in the art, e.g. using a cursor control device and posting

20   messages for browser **104** responsive to certain predetermined cursor control device events. In response, at **304**, browser **104** determines whether the selections were made in reference to the design displayed **108a/108b** or in reference to their dependent graphs **110a/110b**. The determination may also be made in accordance with any one of a number of techniques known in the art, e.g. by having the

25   messages include identification information of the "focus" window at the time the cursor control device events arose.

If it is determined at **304** that the selections were made in reference to the design displayed **108a/108b**, at **306**, browser **104** identifies the dependent graph nodes that are directly associated with the subpart of the mechanical design

5   selected. Additionally, at **308**, browser **104** further identifies all other dependent graph nodes to which the directly associated nodes are dependent on, directly or indirectly, and the arcs that link these nodes to one another. The identification process may be implemented using any one of a number of known "tracing" techniques, to systematically follow the arcs to all the independent nodes on which

10   the directly associated nodes are dependent on. At **310**, browser **104**, refreshes dependant graph display **110a/110b** to reflect the nodes and arcs identified.

Similarly, If it is determined at **304** that the selections were made in reference to the dependent graph displayed **110a/110b**, at **312**, browser **104**

15   determines whether the graphical elements selected are directly associated with specific subparts of the mechanical design. If the graphical elements selected are not directly associated with specific subpart of the mechanical design, at **314**, browser **104** follows the arcs radiating from the selected graphical elements to identify the "nearest" directly associated nodes. Upon either having received

20   identifications of the directly associated nodes directly, or determined the directly associated nodes, at **316**, browser **104** refreshes design display **108a/108b** to highlight the directly associated subparts.

Operations **302-316** may be repeated as many times as it is

25   necessary, alternating between the two basic paths as desired, i.e. selecting subparts of a design and selecting graphical elements of the dependent graph, to

facilitate a designer in exploring and understanding a design. As those skilled in the art will appreciate, the above described novel coordinated approach to facilitate viewing of a design and its dependent graph is particularly useful for facilitating a designer in exploring the various subparts of a design, and reusing selected ones of

5 the subparts in another design.

Referring now to **Figure 4**, wherein a flow diagram illustrating the operational flow of modeler **102** for facilitating reuse of a subpart of one design in another design, in accordance with one embodiment, is shown. As illustrated, at

10 **402**, modeler **102** receives (e.g. by way of browser **104**) certain design subpart reuse related identification inputs from the user. In response, modeler **102**, at **404**, determines whether the inputs are associated with the identification of a subpart of one design to be reused in another design, or the inputs are associated with the identification of a point or an area of a target design on which a subpart of another

15 design is to be inserted or reused.

If it is determined at **404** that the inputs are associated with the identification of a subpart of one design to be reused in another design, at **406**, modeler **102** further determines if the inputs were provided referencing the dependent graph or the modeled design itself. If it is determined at **406** that the

20 inputs were provided referencing the modeled design itself, at **408**, modeler **102** first identifies the dependent graph nodes directly associated with the selected subpart of the design to be reused. If it is determined at **406** that the inputs were provided referencing the dependent graph or upon identifying the directly associated nodes at **408**, at **410**, modeler **102** identifies the dependent graph nodes on which the directly

25 associated nodes are dependent, directly as well as indirectly, and the arcs linking

these nodes to one another. As described earlier, the determination process may be implemented using any one of a number of known "tracing" techniques, to systematically follow the linking arcs to the independent nodes on which the directly associated nodes are dependent. Once all the dependent and independent nodes, and the arcs linking them are identified for the selected subpart to be reused, at **412**, modeler **102** replicates the sub-graph, i.e. creating a copy of the identified dependent and independent nodes, and their linking arcs.

Having replicated the sub-graph, at **414**, modeler **102** determines if the insertion points in the dependent graph of the target design have been determined. If the insertion points have not been identified, at **416**, modeler **102** in cooperation with browser **104** prompts the user to identify the point or area where the subpart is to be reused (i.e. inserted). If the insertion points have been identified, at **418**, modeler **102** attaches the replicated sub-graph to the dependent graph of the target design to reuse the selected subpart with the target design. Lastly, at **420**, modeler **102** refreshes target design's display **108a/108b** as well as the dependent graph display **110a/110b**.

Back at **404**, if it was determined that the inputs received were associated with identifying the insertion point or area of a target design, at **422**, modeler **102** further determines whether the inputs were provided referencing target design's display **108a/108b** or referencing its dependent graph display **110a/110b**. If the inputs were provided referencing target design's display **108a/108b**, at **424**, modeler **102** first identifies the dependent graph nodes directly associated with the

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identified insert point or area of the target design. Upon either determining that the inputs were provided referencing the dependent graph or having identified the dependent graph nodes directly associated with the insertion point/area, at **426**, modeler **102**, further identifies other dependent graph nodes on which the

5   identified/directly associated insertion point nodes are directly or indirectly dependent, and the arcs linking these nodes to each other.

Having identified the insertion points in the dependent graph of the target design, at **428**, modeler **102** determines if the sub-graph modeling the subpart

10   to be reused has been generated (i.e. replicated). If the sub-graph has not been generated, at **430**, modeler **102** in cooperation with browser **104** prompts the user to identify the subpart to be reused. Upon receipt of the identification of the subpart to be reused, the process continues as described earlier. If the sub-graph has been generated, modeler **102** proceeds with the attachment and refresh operations of **418**

15   and **420** as described earlier.

In one embodiment, modeler **102** further provides a user with the opportunity to transform selected ones of the design variables (nodes) from having assigned constant values to being eligible to have their values variably assigned, or

20   vice versa. In one embodiment, modeler **102** offers the transformation option to the user, one applicable design variable at a time, as it processes the independent nodes while performing attachment operation **418**.

Figure 5 illustrates one embodiment of a computer system suitable to be programmed with programming instructions implementing the CAD tool incorporated with the teachings of the present invention. As shown, for the illustrated embodiment, computer **500** includes processor **502**, system bus **506** and

5 I/O bus **510**. System bus **506** and I/O bus **510** are bridged by bus bridge **508**. Coupled to system bus **506** are system memory **514** and video memory **516**, against which video display **518** is coupled. Coupled to I/O bus **510** are disk drive **522**, keyboard and pointing device **524**, and communication interface **526**. Most importantly, computer **500** is programmed with CAD tool **100** incorporated with the

10 teachings of the present invention as described earlier, and operating system **550**.

The elements perform their conventional functions known in the art, except CAD tool **100** perform its otherwise conventional functions in accordance with the present invention. In particular, disk drive **522** and system memory **514** are

15 used to store permanent and working copies of CAD tool **100** and operating system **550**, and video display **518** is used to display e.g. design displays **108a/108b** and dependent graph displays **110a/110b.**. The permanent copies may be pre-loaded into disk drive **522** in a factory, loaded from distribution medium **532**, or down loaded from a remote distribution source (not shown). Distribution medium **532** may be a

20 tape, a CD, a DVD or other storage medium of the like. The constitutions of these elements are known. Any one of a number of implementations of these elements known in the art may be used to form computer system **500**. In alternate embodiments, other components may also be used in addition to or in lieu of the components described, e.g. additional processors. In selected ones of these multi-

25 processor embodiments, execution of the programming instructions implementing

CAD tool **100** incorporated with the teachings of the present invention may also be distributed among the processors.

In general, those skilled in the art will recognize that the present
5   invention is not limited by the details described, instead, the present invention can be practiced with modifications and alterations within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative instead of restrictive on the present invention.

10   Thus, a method and an apparatus for reusing a subpart of one mechanical design in another mechanical design have been described.

CLAIMS

What is claimed is:

1   1.   A method comprising:

2   replicating a sub-graph from a first dependent graph of a first mechanical

3   design, the first dependent graph having modeling information of the first

4   mechanical design and the replicated sub-graph having modeling information of a

5   subpart of the first mechanical design;

6   merging the replicated sub-graph into a second dependent graph of a second

7   mechanical design to reuse the subpart of the first mechanical design in the second

8   mechanical design.

1   2.   The method of claim 1 further comprising receiving identification of the

2   subpart of the first mechanical design, and in response, identifying the sub-graph for

3   replication.

1   3.   The method of claim 2, wherein

2   said first dependent graph includes a first plurality of nodes correspondingly

3   represent a first plurality of design variables of the first mechanical design, and a

4   first plurality of arcs linking the first plurality of nodes in accordance with the first

5   plurality of design variables' dependency on one another; and

6   said identification of the sub-graph for replication comprises correlating said

7   received identification of the subpart to one or more nodes of said first plurality of

8   nodes directly associated with the subpart, and following applicable ones of said first

9   plurality of arcs to identify all other nodes of said first plurality of nodes to which the

10   directly associated nodes are directly or indirectly dependent on.

1   4.   The method of claim 3 wherein said replication comprises copying said

2   directly associated nodes, said nodes on which the directly associated nodes are

3   dependent on, and the arcs linking these nodes to one another.

1   5.   The method of claim 4, wherein

2   selected ones of the design variables of said replicated sub-graph are set to

3   constant values, while others are eligible to have values variably assigned; and

4   the method further comprises receiving instructions to transform selected

5   ones of the design variables set to constant values to design variables eligible for

6   having values variably assigned, or to transform selected ones of the design

7   variables eligible for having values variably assigned to having constant values

8   assigned.

1   6.   The method of claim 1 further comprising receiving identification of a point or

2   an area of the second mechanical design to reuse the subpart of the first

3   mechanical design in the second mechanical design.

1   7.   The method of claim 6, wherein

2   said second dependent graph includes a second plurality of nodes

3   correspondingly represent a second plurality of design variables of the second

4   mechanical design, and a second plurality of arcs linking the second plurality of

5   nodes in accordance with the second plurality of design variables' dependency on

6   one another; and

7   said merging comprises correlating said received identification of the

8   point/area to one or more nodes of said second plurality of nodes directly associated

9   with the identified point/area, and attaching the replicated sub-graph to the second

10   dependent graph by selectively linking nodes of the replicated sub-graph to the

11   correlated nodes of the second dependent graph.

1   8.   An article of manufacture comprising:

2   a recordable medium having recorded thereon a plurality of programming

3   instructions for use to program an apparatus to enable the apparatus to be able to

4   replicate a sub-graph from a first dependent graph of a first mechanical design, the

5   first dependent graph having modeling information of the first mechanical design

6   and the replicated sub-graph having modeling information of a subpart of the first

7   mechanical design, and to be able to merge the replicated sub-graph into a second

8   dependent graph of a second mechanical design to reuse the subpart of the first

9   mechanical design in the second mechanical design.

1   9.   The article of claim 8, wherein the programming instructions further enable

2   the apparatus to be able to receive identification of the subpart of the first

3   mechanical design, and in response, identify the sub-graph for replication.

1   10.   The article of claim 9, wherein

2   said first dependent graph includes a first plurality of nodes correspondingly

3   represent a first plurality of design variables of the first mechanical design, and a

4   first plurality of arcs linking the first plurality of nodes in accordance with the first

5   plurality of design variables' dependency on one another; and

6   the programming instructions further enable the apparatus to be able to

7 identify the sub-graph for replication by correlating said received identification to one

8 or more nodes of said first plurality of nodes directly associated with the subpart,

9 and then following applicable ones of said first plurality of arcs to identify all other

10 nodes of said first plurality of nodes to which the directly associated nodes are

11 directly or indirectly dependent on.

1 11.   The article of claim 10 wherein the programming instructions further enable

2 the apparatus to be able to replicate the identified sub-graph by copying said directly

3 associated nodes, said nodes the directly associated nodes are dependent on, and

4 the arcs linking these nodes to one another.

1 12.   The article of claim 11, wherein

2 selected ones of the design variables of said replicated sub-graph are set to

3 constant values, while others are eligible to have values variably assigned; and

4 the programming instructions further enable the apparatus to be able to

5 receive instructions to transform selected ones of the design variables set to

6 constant values to design variables eligible for having values variably assigned, or to

7 transform selected ones of the design variables eligible for having values variably

8 assigned to having constant values assigned.

1 13.   The article of claim 8, wherein the programming instructions further enable

2 the apparatus to be able to receive identification of a point or an area of the second

3 mechanical design to reuse the subpart of the first mechanical design in the second

4 mechanical design.

1 14.   The article of claim 13, wherein

2   said second dependent graph includes a second plurality of nodes

3   correspondingly represent a second plurality of design variables of the second

4   mechanical design, and a second plurality of arcs linking the second plurality of

5   nodes in accordance with the second plurality of design variables' dependency on

6   one another; and

7   the programming instructions further enable the apparatus to be able to

8   correlate the received identification of the point/area to one or more nodes of said

9   second plurality of nodes directly associated with the identified point/area, and to

10   attach the replicated sub-graph to the second dependent graph by selectively linking

11   nodes of the replicated sub-graph to the correlated nodes of the second dependent

12   graph.

1   15.   The article of claim 8, wherein the programming instructions are integral part

2   of a computer aided design tool.

1   16.   An apparatus comprising:

2   at least one storage medium having stored therein a first and a second

3   plurality of programming instructions; and

4   at least one processor coupled to the at least on storage medium to execute

5   the first plurality of programming instructions to replicate a sub-graph from a first

6   dependent graph of a first mechanical design, the first dependent graph having

7   modeling information of the first mechanical design and the replicated sub-graph

8   having modeling information of a subpart of the first mechanical design, and to

9   execute the second plurality of programming instructions to merge the replicated

10   sub-graph into a second dependent graph of a second mechanical design to reuse

11   the subpart of the first mechanical design in the second mechanical design.

1   17.   The apparatus of claim 16, wherein the at least one processor further

2   executes the second plurality of programming instructions to receive identification of

3   the subpart of the first mechanical design, and in response, identify the sub-graph

4   for replication.

1   18.   The apparatus of claim 17, wherein

2   said first dependent graph includes a first plurality of nodes correspondingly

3   represent a first plurality of design variables of the first mechanical design, and a

4   first plurality of arcs linking the first plurality of nodes in accordance with the first

5   plurality of design variables' dependency on one another; and

6   the at least one processor further executes the first plurality of programming

7   instructions to identify the sub-graph for replication by correlating said received

8   identification of the subpart to one or more nodes of said first plurality of nodes

9   directly associated with the identified subpart, and to follow applicable ones of said

10   first plurality of arcs to identify all other nodes of said first plurality of nodes to which

11   the directly associated nodes are directly or indirectly dependent on.

1   19.   The apparatus of claim 18 wherein the at least one processor further

2   executes the first plurality of programming instructions to replicate the identified sub-

3   graph by copying said directly associated nodes, said nodes on which the directly

4   associated nodes are dependent on, and the arcs linking the these nodes to one

5   another.

1   20.   The apparatus of claim 19, wherein

2   selected ones of the design variables of said replicated sub-graph are set to

3   constant values, while others are eligible to have values variably assigned; and

4   the at least one processor further executes the second plurality of

5   programming instructions to receive instructions to transform selected ones of the

6   design variables set to constant values to design variables eligible for having values

7   variably assigned, or to transform selected ones of the design variables eligible for

8   having values variably assigned to having constant values assigned.

1   21.   The apparatus of claim 16, wherein the at least one processor further

2   executes the second plurality of programming instructions to receive identification of

3   a point or an area of the second mechanical design to reuse the subpart of the first

4   mechanical design in the second mechanical design.

1   22.   The apparatus of claim 21, wherein

2   said second dependent graph includes a second plurality of nodes

3   correspondingly represent a second plurality of design variables of the second

4   mechanical design, and a second plurality of arcs linking the second plurality of

5   nodes in accordance with the second plurality of design variables' dependency on

6   one another; and

7   the at least one processor further executes the second plurality of

8   programming instructions to correlate the received identification of the point/area to

9   one or more nodes of said second plurality of nodes directly associated with the

10   identified point/area, and to attach the replicated sub-graph to the second

11   dependent graph by selectively linking nodes of the replicated sub-graph to the

12   correlated nodes of the second dependent graph.

1   23.   The apparatus of claim 16, wherein the at least one processor consists of a

2   processor executing both the first and second plurality of programming instructions.

1   24.   The apparatus of claim 16, wherein the at least one processor comprises a

2   first and a second processor communicatively coupled to each other to

3   correspondingly execute the first and second plurality of programming instructions.

1   25.   An apparatus comprising:

2   means to replicate a subset of a first modeling representation of a first

3   mechanical design responsive to instructions identifying a subpart of the first

4   mechanical design;

5   means to merge the replicated subset into a second modeling representation

6   of a second mechanical design to reuse the identified subpart of the first mechanical

7   design in the second mechanical design.

1   26.   A method comprising the steps of:

2   replicating a subset of a first modeling representation of a first mechanical

3   design responsive to instructions identifying a subpart of the first mechanical design;

4   and

5   merging the replicated subset into a second modeling representation of a

6   second mechanical design to reuse the identified subpart of the first mechanical

7   design in the second mechanical design.

1

ABSTRACT OF THE DISCLOSURE

A mechanical design reuse method includes having a CAD tool replicates a subset of a first modeling representation of a first mechanical design, in

5 response to having received instructions that identify a subpart of the first mechanical design. The reuse method further includes having the CAD tool merges the replicated subset into a second modeling representation of a second mechanical design to effectuate the reuse of the identified subpart of the first mechanical design in the second mechanical design. In one embodiment, the modeling

10 representations are dependent graphs, and the subsets being replicated and merged are sub-graphs of the dependent graphs. The dependent graphs and sub-graphs include nodes directly associated with the subparts of the designs, nodes on which the directly associated nodes are dependent, and arcs linking the nodes together in accordance with their dependency on each other. In one embodiment,

15 the replicate and merging process also provides for a designer the option to transform certain design variables having constant values assigned to become design variables eligible to have their values variably assigned, and vice versa.

FIG. 1

GRAPH DATABASE 250

204 3 Cu
204 <User input>

LENGTH OF
ELEMENT TYPE

Wire 206

LENGTH OF
LENGTH OF
ELEMENT TYPE
ELEMENT TYPE
ELEMENT TYPE

208 LENGTH OF

A 202
B 202
C 202
D 202

⊥
⊥
=
=
⊥
⊥

202 206a 206b 208

FIG. 2c
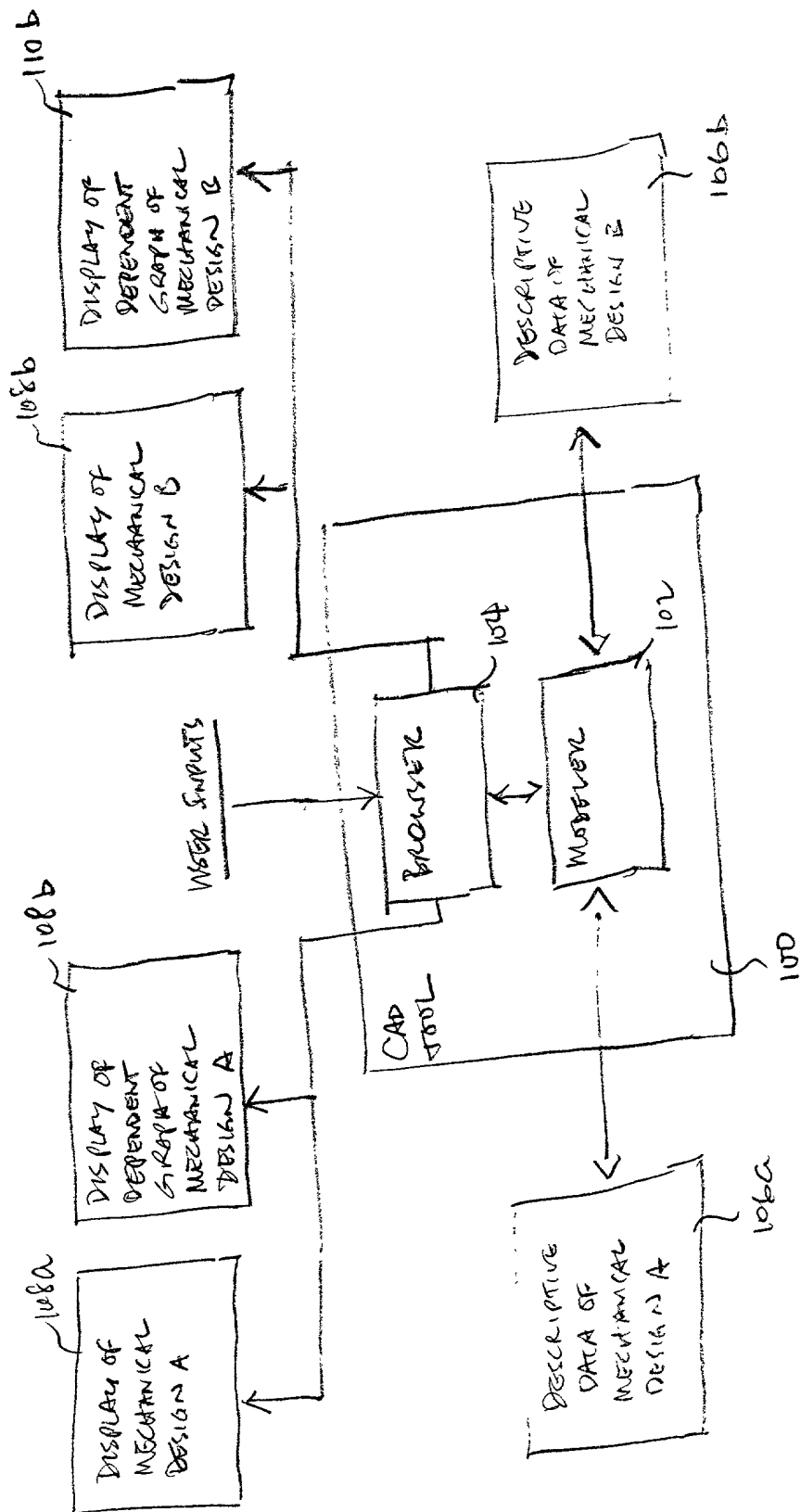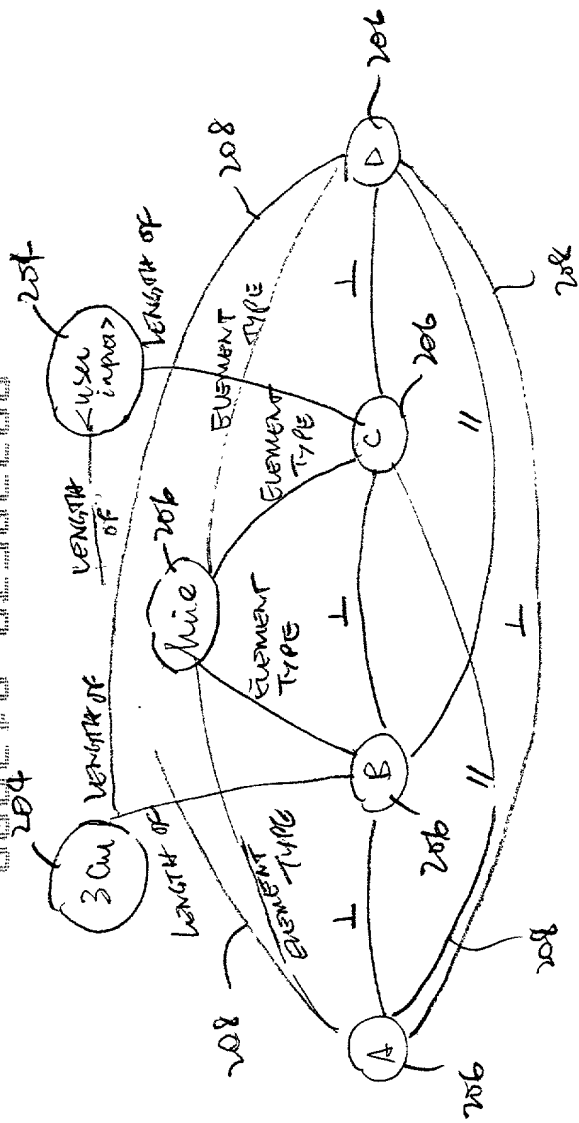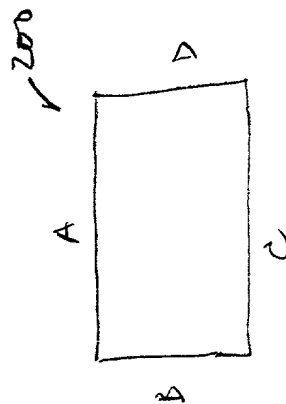
ELEMENT ID	ELEMENT TYPE	LENGTH	CONSTRAINTS
A	Line	\<user\>	⊥B, ⊥D, ∥C
B	Line	3 cm	⊥A, ⊥C, ∥D
C	Line	\<user\>	⊥B, ⊥D, ∥A
D	Line	2 cm	⊥A, ⊥C, ∥B

FIG. 2b

200

A ——— D

B ——— C

FIG. 2a

RECEIVED USER SELECTION? — 302

NO

YES

DESIGN DISPLAY GRAPIC DISPLAY? — 304

DESIGN DISPLAY

IDENTIFY DIRECTLY ASSOCIATED NODES — 306

IDENTIFY NODES ON WHICH DIRECTLY ASSOCIATED NODES ARE DEPENDENT ON & LINKING ARCS — 308

GRAPIC DISPLAY

NODES HAVING DIRECT ASSOCIATION WITH DESIGN? — 312

NO

IDENTIFY DEPENDENT NODES WITH DIRECT ASSOCIATION — 314

HIGHLIGHT THE IDENTIFIED NODES & THEIR LINKING ARCS — 310

YES

HIGHLIGHT THE DIRECTLY ASSOCIATED SUBPART OF DESIGN — 316

Fig. 3

FIG. 4

A → RECEIVE USER INPUTS RELATED TO REUSING SUBPART OF A DESIGN — 402

INPUTS ASSOCIATED WITH SUBPARTS TO BE REUSED OR INSERTION POINT? — 404

— SUBPART → REFERENCING DESIGN OR DEPT. GRAPH? — 406

— DESIGN → IDENTIFY DIRECTLY ASSOCIATED NODES — 408

— GRAPH → IDENTIFY NODES ON WHICH DIRECTLY ASSOCIATED NODES ARE DEPENDENT ON & LINKING ARCS — 410

REPLICATE SUB-GRAPH — 412

INSERTION POINT KNOWN? — 414

— NO → PROMPT USER TO IDENTIFY REUSE LOCATION — 416

— INSERTION POINT → REFERENCING DESIGN OR DEPT. GRAPH? — 422

— DESIGN → IDENTIFY DIRECTLY ASSOCIATED NODES — 424

— GRAPH → IDENTIFY NODES ON WHICH DIRECTLY ASSOCIATED NODES ARE DEPENDENT ON & LINKING ARCS — 426

SUB-GRAPH REPLICATED? — 428

PROMPT USER TO TO IDENTIFY REUSE SUBPART — 430

A

ATTACH SUB-GRAPH TO DEPENDENT GRAPH OF TARGET DESIGN — 418

REFRESH TARGET DESIGN — 420

MEMORY 514

CAD TOOL 100

OPERATING SYSTEM 550

PROCESSOR(S) 502

506

BUS BRIDGE 508

VIDEO RAM 516

DISPLAY 518

DESIGNS

GRAPHICS

1082/1082b

1106/1106b

510

COMM INTF. 525

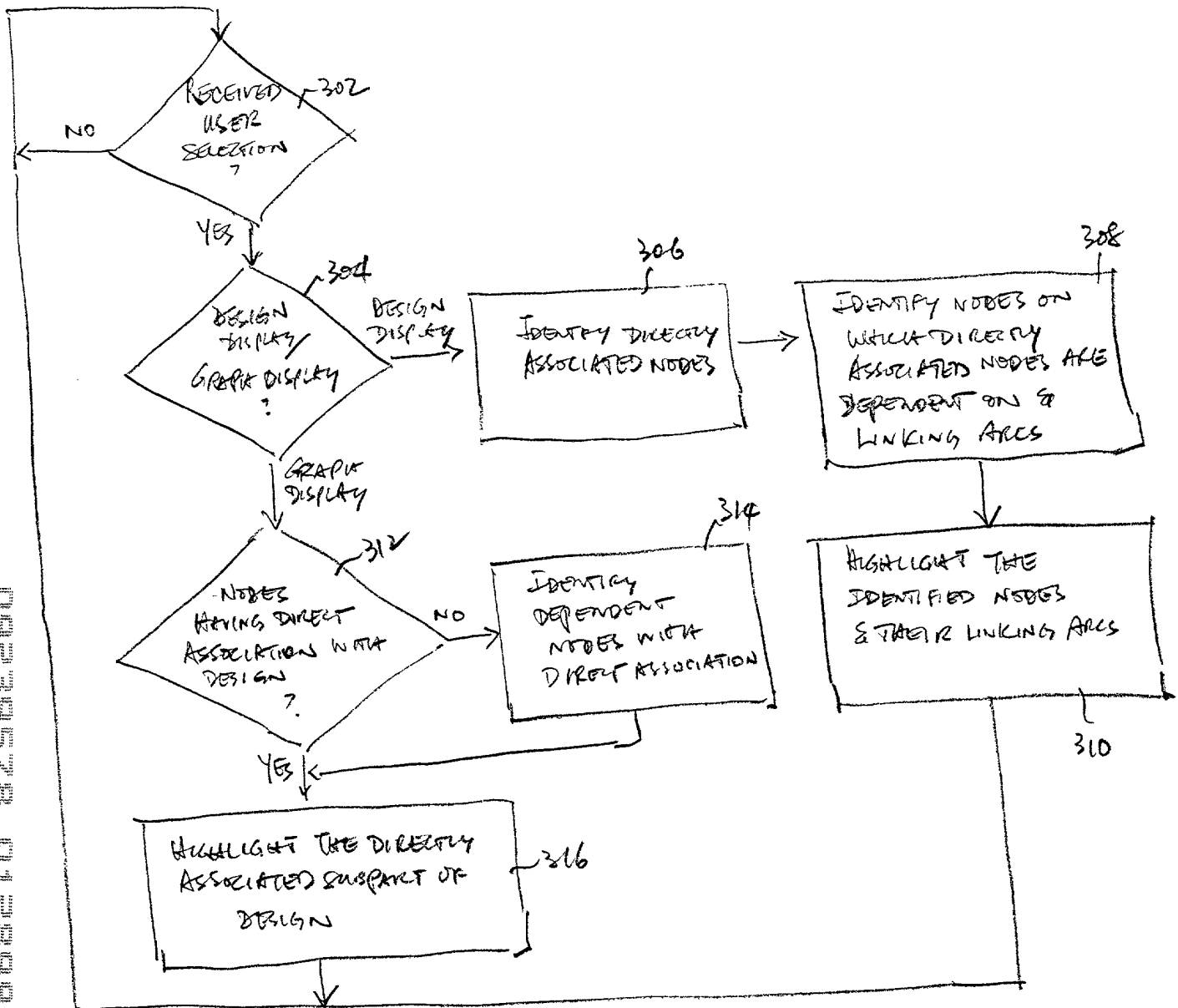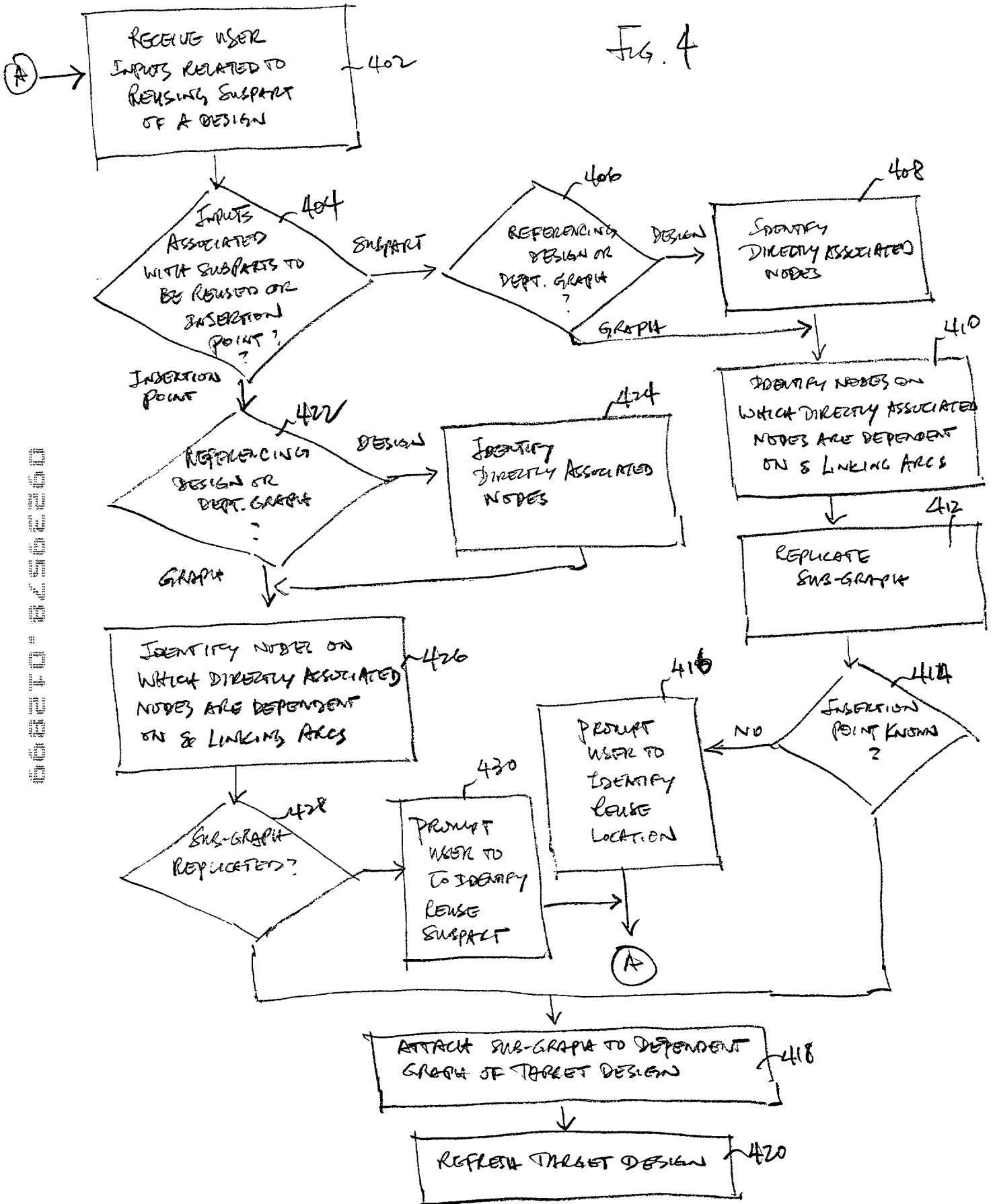KB & CURSOR CONTROL 522
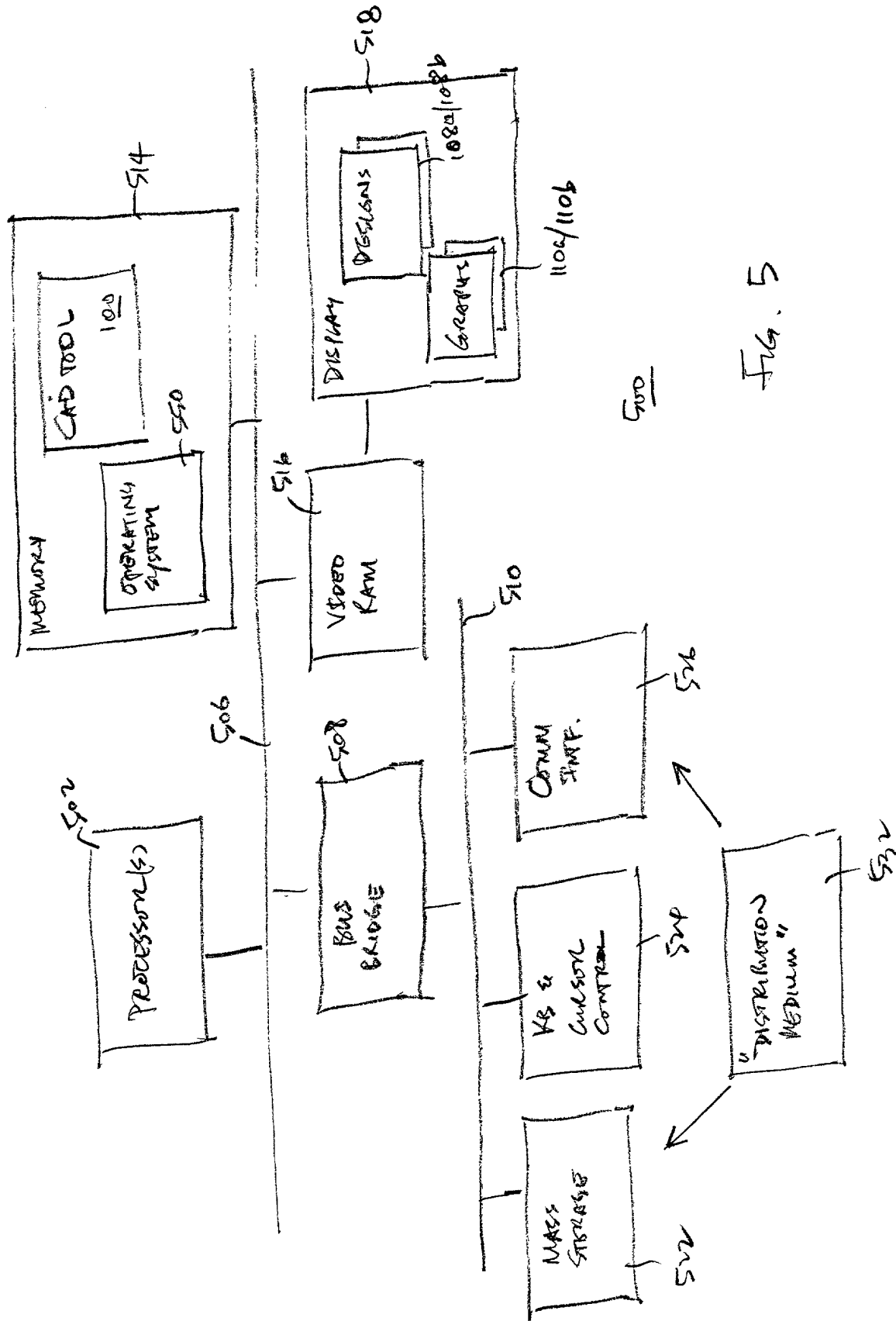
MASS STORAGE 512

"DISTRIBUTION MEDIUM" 530

500

FIG. 5

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD AND APPARATUS FOR REUSING SUBPARTS OF ONE MECHANICAL DESIGN FOR ANOTHER MECHANICAL DESIGN

the specification of which

    __X__   is attached hereto.
    ___   was filed on _____ as
           United States Application Number _____
           or PCT International Application Number_____
           and was amended on _____.
                               (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below

_____   _____
(Application Number)   Filing Date

_____   _____
(Application Number)   Filing Date

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

_____   _____   _____
(Application Number)   Filing Date   (Status -- patented,
                                                         pending, abandoned)

_____   _____   _____
(Application Number)   Filing Date   (Status -- patented,
                                                         pending, abandoned)

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Send correspondence to ___Aloysius T.C. AuYeung_____, BLAKELY, SOKOLOFF, TAYLOR &
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                              (Name of Attorney or Agent)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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                    _____

Full Name of Fourth/Joint Inventor _____

Inventor's Signature _____ Date _____

Residence _____ Citizenship _____
                              (City, State)   (Country)

Post Office Address _____
                    _____

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